WHAT IS CLAIMED IS:

1. An attitude sensing apparatus having a GPS attitude sensing system which determines the attitude of a mobile unit in a reference coordinate system and an IMU attitude sensing system which determines the attitude of the mobile unit in the reference coordinate system and determining the attitude of the mobile unit by integrating the attitudes of the mobile unit determined in the individual coordinate systems, said attitude sensing apparatus comprising:

an alignment angle estimator for successively estimating an alignment angle to be used in a succeeding calculation process based on the difference between inertia data calculated from observations by said GPS attitude sensing system and inertia data observed by said IMU attitude sensing system; and

an alignment angle adder for generating an updated alignment angle by cumulatively adding the successively estimated alignment angle and thereby updating the estimated alignment angle in sequence and for outputting the updated alignment angle to said alignment angle estimator;

wherein the estimated alignment angle is successively fed back for use in the alignment angle estimation process.

2. The attitude sensing apparatus according to claim 1, wherein individual components θ_x, θ_y, θ_z of the alignment angle satisfy the following conditions:

$-85° \leq \theta_x \leq 85°$,

$-85° \leq \theta_y \leq 85°$,

$-85° \leq \theta_z \leq 90°$

and the estimated alignment angle is successively fed back together with the updated alignment angle for use in the alignment angle estimation process.

3. The attitude sensing apparatus according to claim 1 or 2, wherein said alignment angle estimator successively estimates a sensor error caused by an inertia sensor of said IMU attitude sensing system from the estimated alignment angle, said attitude sensing apparatus further comprising:

a sensor error adder for generating an updated sensor error by cumulatively adding the successively estimated sensor error and thereby updating the estimated sensor error in sequence and for outputting the updated sensor error to said alignment angle estimator;

wherein the updated sensor error is successively fed back for use in the alignment angle estimation process.

4. The attitude sensing apparatus according to claim 1 further comprising:

a setter for setting a provisional alignment angle upon installation of a GPS antenna of said GPS attitude sensing system and an inertia sensor of said IMU attitude sensing system;

wherein initial conditions for said alignment angle estimator are set by using the provisional alignment angle.

5. The attitude sensing apparatus according to claim 1, wherein the alignment angle estimation process is performed until the alignment angle is finally determined.

6. An attitude sensing apparatus for determining the attitude of a mobile unit, comprising:

a GPS attitude sensing system which determines the attitude of the mobile unit in the reference coordinate system;

an IMU attitude sensing system which determines the attitude of the mobile unit in the reference coordinate system;

an alignment angle estimator for successively estimating an alignment angle to be used in a succeeding calculation process based on the difference between inertia

data calculated from observations by said GPS attitude sensing system and inertia data observed by said IMU attitude sensing system; and

an alignment angle adder for generating an updated alignment angle by cumulatively adding the successively estimated alignment angle and thereby updating the estimated alignment angle in sequence and for outputting the updated alignment angle to said alignment angle estimator;

wherein the estimated alignment angle is successively fed back for use in the alignment angle estimation process.

7. The attitude sensing apparatus according to claim 6, wherein individual components θ_x, θ_y, θ_z of the alignment angle satisfy the following conditions:

$-85° \leq \theta_x \leq 85°$,

$-85° \leq \theta_y \leq 85°$,

$-85° \leq \theta_z \leq 90°$

and the estimated alignment angle is successively fed back together with the updated alignment angle for use in the alignment angle estimation process.

8. The attitude sensing apparatus according to claim 6 or 7, wherein said alignment angle estimator successively estimates a sensor error caused by an inertia sensor of said

IMU attitude sensing system from the estimated alignment angle, said attitude sensing apparatus further comprising:

a sensor error adder for generating an updated sensor error by cumulatively adding the successively estimated sensor error and thereby updating the estimated sensor error in sequence and for outputting the updated sensor error to said alignment angle estimator;

wherein the updated sensor error is successively fed back for use in the alignment angle estimation process.

9. The attitude sensing apparatus according to claim 6 further comprising:

a setter for setting a provisional alignment angle upon installation of a GPS antenna of said GPS attitude sensing system and an inertia sensor of said IMU attitude sensing system;

wherein initial conditions for said alignment angle estimator are set by using the provisional alignment angle.

10. The attitude sensing apparatus according to claim 6, wherein the alignment angle estimation process is performed until the alignment angle is finally determined.

11. A method for attitude sensing including a GPS attitude sensing system which determines the attitude of a mobile unit in the reference coordinate system and an IMU attitude sensing system which determines the attitude of the mobile unit in the reference coordinate system and determining the attitude of the mobile unit by integrating the attitudes of the mobile unit determined in the individual coordinate systems, said method comprising the steps of:

estimating successively an alignment angle to be used in a succeeding calculation process based on the difference between inertia data calculated from observations by said GPS attitude sensing system and inertia data observed by said IMU attitude sensing system; and

generating an updated alignment angle by cumulatively adding the successively estimated alignment angle and thereby updating the estimated alignment angle in sequence and for outputting the updated alignment angle to said alignment angle estimator;

wherein the estimated alignment angle is successively fed back for use in the alignment angle estimation process.

12. The attitude sensing method according to claim 11, wherein individual components θ_x, θ_y, θ_z of the alignment angle satisfy the following conditions:

$-85° \leq \theta_x \leq 85°$,

$-85° \leq \theta_y \leq 85°$,

$-85° \leq \theta_z \leq 90°$

and the estimated alignment angle is successively fed back together with the updated alignment angle for use in the alignment angle estimation process.

13. The attitude sensing method according to claim 11 or 12, wherein there are successive estimates of a sensor error caused by an inertia sensor of said IMU attitude sensing system from the estimated alignment angle, said method further comprising:

generating an updated sensor error by cumulatively adding the successively estimated sensor error and thereby updating the estimated sensor error in sequence and outputting the updated sensor error;

wherein the updated sensor error is successively fed back for use in the alignment angle estimation process.

14. The attitude sensing method according to claim 11 further comprising:

setting a provisional alignment angle upon installation of a GPS antenna of said GPS attitude sensing system and an inertia sensor of said IMU attitude sensing system;

wherein initial conditions for said alignment angle estimator are set by using the provisional alignment angle.

15. The attitude sensing method according to claim 11, wherein the alignment angle estimation process is performed until the alignment angle is finally determined.

16. An attitude sensing method for determining the attitude of a mobile unit, comprising the steps of:

determining the attitude of the mobile unit in the reference coordinate system with a GPS attitude sensing system;

determining the attitude of the mobile unit in the reference coordinate system with an IMU attitude sensing system;

estimating successively an alignment angle to be used in a succeeding calculation process based on the difference between inertia data calculated from observations by said GPS attitude sensing system and inertia data observed by said IMU attitude sensing system; and

generating an updated alignment angle by cumulatively adding the successively estimated alignment angle and thereby updating the estimated alignment angle in sequence and for outputting the updated alignment angle to said alignment angle estimator;

wherein the estimated alignment angle is successively fed back for use in the alignment angle estimation process.

17. The attitude sensing method according to claim 16, wherein individual components θ_x, θ_y, θ_z of the alignment angle satisfy the following conditions:

$-85° \leq \theta_x \leq 85°$,

$-85° \leq \theta_y \leq 85°$,

$-85° \leq \theta_z \leq 90°$

and the estimated alignment angle is successively fed back together with the updated alignment angle for use in the alignment angle estimation process.

18. The attitude sensing method according to claim 16 or 17, wherein there are successive estimates of a sensor error caused by an inertia sensor of said IMU attitude sensing system from the estimated alignment angle, said attitude sensing method further comprising:

generating an updated sensor error by cumulatively adding the successively estimated sensor error and thereby updating the estimated sensor error in sequence and for outputting the updated sensor error;

wherein the updated sensor error is successively fed back for use in the alignment angle estimation process.

19. The attitude sensing method according to claim 16 further comprising:

setting a provisional alignment angle upon installation of a GPS antenna of said GPS attitude sensing system and an inertia sensor of said IMU attitude sensing system;

wherein initial conditions for said alignment angle estimator are set by using the provisional alignment angle.

20. The attitude sensing method according to claim 16, wherein the alignment angle estimation process is performed until the alignment angle is finally determined.